

## UNI-DIRECTIONAL FLUID VALVE

## BACKGROUND OF THE INVENTION

The present invention relates to a uni-directional fluid valve which may in particular be used as an exhalation valve for a filter mask. By a "filter mask" we mean a device adapted to be worn over the nose and mouth of a user and made from or incorporating a filter material to remove one or more unwanted components from the inspired air. To improve the comfort and efficiency of such devices it is common to provide a uni-directional exhalation valve on the mask which opens under the pressure differential consequent upon exhalation of the user to allow for a relatively unrestricted flow of exhalate out of the mask, but which closes under other conditions. Examples of valved filter masks are shown in GB-2072516, DE-4029939, U.S. Pat. No. 4,414,973, U.S. Pat. No. 4,838,262, U.S. Pat. No. 4,873,972, U.S. Pat. No. 4,934,362, U.S. Pat. No. 4,958,633, U.S. Pat. No. 4,974,586, U.S. Pat. No. 4,981,134 and U.S. Pat. No. 5,325,892.

A common type of exhalation valve comprises a circular diaphragm of e.g. silicone rubber and a cooperating circular valve seat surrounding the orifice which passes the user's exhalate. The diaphragm is clamped at its centre and marginal portions flex away from the seat when the user exhales. In another known type the diaphragm is in the form of a flexible flap which is attached to a cooperating seat structure at one end, that is to say in cantilever fashion, and flexes away from the rest of the seat when the user exhales. In the design of an exhalation valve it is important to maximise the cross-sectional area of the open orifice to allow free flow of exhalate through the valve, and also to minimise the differential air pressure required to open the valve (i.e. the valve "cracking" pressure). Centrally clamped diaphragm valves require a greater force to open them than cantilevered flap type valves of equivalent size because their available "lever arm" is less. Furthermore, the structure of a cantilevered flap type valve, when open, generally presents less of an obstruction to flow than the centrally clamped circular diaphragm type valve, or in other words imposes a smaller pressure drop for a given orifice size. A potential problem which must be addressed in the design of a cantilevered flap valve, however, lies in ensuring that the flap will remain closed in all orientations of the structure while it is not subject to an exhalatory pressure differential. That is to say, while in order to minimise the opening pressure differential of the valve it is desirable to employ a highly flexible flap of minimal thickness, the very flexibility of the flap may mean that if the valve is inverted in use (i.e. orientated with the seat lying above the flap), the flap may droop down from the seat when the user is not exhaling. This is clearly undesirable as it may open a leakage path into the mask for the contaminants which it is intended to exclude.

U.S. Pat. No. 5,325,892 discloses an exhalation valve with a cantilevered flap in which the valve seat has a seal ridge which is curved in the longitudinal direction of the flap, the curvature corresponding to a deformation curve exhibited by the flap when it bends under its own weight (with no pressure differential). In other words the design of that valve recognises that the flap is unable to stay flat when the structure is inverted and matches the configuration of the seat to the curvature of the flap under that condition.

## SUMMARY OF THE INVENTION

In accordance with the present invention a uni-directional fluid valve comprises a flexible flap and a cooperating valve

seat surrounding an orifice adapted to pass a fluid; the flap being attached to the seat at one end, in cantilever fashion, and being adapted to flex away from other portions of the seat when fluid flows in the permitted direction; and wherein there is a transverse curvature to at least the said one end of the flap whereby to maintain the flap substantially seated in the absence of a pressure differential across it, in any orientation of the valve.

The effect of the transverse curvature of the flap in a valve according to the invention is therefore to stiffen the flap sufficiently to resist any drooping away from the seat when there is no applied pressure differential, even in the inverted orientation of the structure. As soon as the flap is "cracked" by an appropriate pressure differential, however, the free end of the flap will rapidly flex away from the seat and this flexure will progress along the length of the flap to a position determined by the instantaneous rate of fluid flow. At least the root end of the flap, at its position of attachment to the seat, will retain its transverse curvature however, and this will apply a restorative force to the flexed flap, assisting to reseat the flap when the permitted flow of fluid ceases. The stiffening effect of this transverse curvature is therefore to be distinguished from the longitudinal curvature of the flap in U.S. Pat. No. 5,325,892.

The flap for a valve according to the invention may be manufactured to exhibit the requisite transverse curvature in its natural state, e.g. by means of injection moulding or thermoforming. In the preferred embodiment to be described hereinafter, however, the flap as manufactured is flat and its curvature is imparted in use by means of the shaping of the valve structure in which it is mounted.

## BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be more particularly described, by way of example, with reference to the accompanying schematic drawings, in which:

FIG. 1 is a perspective view of a filter mask incorporating a uni-directional valve in accordance with the invention as an exhalation valve;

FIG. 2 is an "exploded" isometric view of the components of a preferred embodiment of the exhalation valve for the mask of FIG. 1;

FIG. 3 is an isometric view showing the interior of the upper housing member of FIG. 2;

FIG. 4 is a longitudinal section through the valve assembled from the components of FIG. 2, on the line IV—IV of FIG. 5, in the closed condition; and

FIG. 5 is a section on the line V—V of FIG. 4.

## DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIG. 1, the illustrated mask 1 is made from one or more layers of flexible sheet filter material cut from a blank, folded and welded to form a cup-shaped structure to be worn over the nose and mouth of the user. It is in particular shaped in accordance with the invention in GB-2046102, to which reference is directed for a fuller description of the method of forming the mask from a flat blank. In use the peripheral edge of the mask forms a seal against the wearer's face and it is held in place by elastic headbands 2 and a deformable wire nose clip 3 as well known in the art.

At a suitable location in the side wall of the mask 1 an aperture is formed in which an exhalation valve 4 is fitted, the structure of which is more clearly illustrated in FIGS. 2 to 5.